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APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

ARTICULATED SLIP RAM FOR TAPERED COILED TUBING

BY

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[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 60/421,986 filed October 29, 2002.

FIELD OF THE INVENTION

[0002] The present invention relates generally to the field of blowout preventers for tubing, and, more particularly, to a slip ram in a blowout preventer adapted to accommodate tubing which tapers or otherwise varies in its outside diameter.

BACKGROUND OF THE INVENTION

[0003] The use of blowout preventers in drilling, completion, workover, and production of oil and gas wells is well known. Such blowout preventers generally include a housing with a bore extending through the housing. Opposed chambers extend laterally on either side of the bore in the housing and communicate with the bore. Rams within the chambers are connected to rods that are supported for moving the rams inwardly into the bore to close off the bore. This action divides the bore into a zone above the rams and a zone below the rams. The rods also serve to retract outwardly from the bore to open the bore.

[0004] Various types of rams may be employed such as those which engage circumferentially around a pipe or tubular member for sealing engagement with the tube or pipe, while others are provided with cutting surfaces for shearing tubular members or cables which extend through the bore of the blowout preventer.

[0005] Blowout preventers (BOPs) are also commonly used in coiled tubing systems. Such BOPs provide a means of holding the tubing and isolating the well bore pressure during a variety of conditions, including emergencies. The configuration of the BOP rams and sideport facility allows well-control operations to be conducted under a variety of conditions.

[0006] Newer blowout preventers include four sets of rams, which may be referred to

herein as a "Quad BOP". The system comprises a set of four stacked elements, each with a different function. Blind rams are shut when there is no tubing or tool string extending through the body of the BOP. Shear rams are designed to close on and cut through the tubing. Slip rams close on and hold the tubing, ideally without damaging the surface of the piping or other tubular member. Finally, pipe rams seal around the tubing when it is in place. Each of the rams should only be actuated when the tubing is stationary; otherwise, damage to either the BOP or the tubing is likely. Of the four types of rams just described, the present invention is directed to the slip ram type for use with tubing.

[0007] As previously explained, a slip ram closes onto a tubular, and in the case of the present invention, closes on and holds tubing. Slip segments to grip and suspend coiled tubing are well known and widely used in coiled tubing applications. The slips are typically installed in a set of rams. The slips are most often made in two pieces, one piece in each ram, with gripper teeth on the semi circle resulting in near 360° coverage of the coiled tubing diameter. The gripper section is machined to a specific inside diameter to match the outside diameter of the coiled tubing. This system works reasonably well as long as the coiled tubing is of a constant diameter. Over-worked coiled tubing may become undersized, oversized, or out of round, all of which reduce, or negate the effectiveness of the slip segment gripper teeth.

[0008] Furthermore, recent innovations have provided tubing which has a substantially constant inside diameter, but a substantially constantly increasing outside diameter, so that the tubing presents a tapered aspect in its outside diameter. Development of such a tapered outside diameter coiled tubing renders the gripping system with a set diameter unworkable. In other words, with a first length of tubing through the slip ram, a relatively small diameter of tubing must be accommodated by the slip ram. However, with a longer length of tubing down hole, a larger diameter of tubing must be grasped and held. Current structures of slip rams offer a set diameter of the ram, provided in equal halves on either side of the tubular, and this is incapable of accommodating the varying diameter of tubing which is presented to the slip ram, if the outside diameter of the tubing varies with length. It is believed that the prior art has failed to solve, or even address this problem.

SUMMARY OF THE INVENTION

[0009] The present invention addresses these and other needs and drawbacks in the prior art by providing a slip and a method of gripping tubing having a varying outside diameter. The slip is configured to be retrofitted on existing slip rams in the field so save on costs, and to accommodate such varying diameter tubing when called for by a specific job.

[0010] In a first aspect, the present invention comprises an articulated slip for a slip ram. The slip includes a plurality of articulated elements, attached to vertical pins or axles which are parallel to the axis of the tubular, for rotatable movement. The articulated elements are concave for abutting contact with a tubular through the slip ram. The pins around mounted to a slip ram, which comprises a piston within a cylinder, in the conventional manner for a blowout preventer (BOP) ram. When the slip ram is actuated, the ram moves forward, wrapping the articulated elements around the tubular in a gripping motion, much like the fingers of a human hand.

[0011] The present invention provides a further innovation, other than providing a slip which can grasp a tubular with a varying outside diameter or out of round diameter, and that innovation deals with the irregular surface within the ram itself which contacts the tubing. Although slip rams ideally do not damage the tubing surface of the tubular member through the BOP, it has been found that even a single actuation of the slips against the tubing can score the exterior surface of the tubing. In today's high performance operations at elevated pressures, this scoring can reduce the useful lifetime of the tubular member, particularly with coiled tubing. The interior surface of slips commonly in use today comprises a series of parallel horizontal toothed surfaces, or a series of threads in a substantially horizontal orientation, to contact the tubular and prevent vertical, *i.e.* axial movement of the tubular. The present invention is further directed to reducing the scoring on the outside surface of the tubular by the slips when engaging and disengaging.

[0012] Thus, in another aspect of the invention, a method of retaining a tapered tubular within a well bore is provided, wherein an articulated slip is impressed upon the tubular by wrapping the slip around the tapered tubular, the extent of closure of the slip

determined solely by the outside diameter of the tubular. In a still further aspect of the invention, a cast or molded slip surface comprises a plurality of cleats defining a conical aspect up to a substantially spherical apex of the cone, in order to develop point loading of the cleats on the outside surface of the tubular, rather than the scoring action of linear lands of threads on the surface of the slip, as common in the art.

[0013] These and other features and advantages of this invention will be readily apparent to those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, more particular description of the invention, briefly summarized above, may be had by reference to embodiments thereof which are illustrated in the appended drawings.

[0015] Figure 1 is an elevation section view of an actuator and coiled tubing slip ram constructed in accordance with the teachings of the present invention.

[0016] Figure 2 is a top view, in partial section, of a set of slips, *i.e.* from both sides of a tubular, of the present invention.

[0017] Figure 3 is a front elevation view, *i.e.* toward an actuator, of the slip of this invention.

[0018] Figure 3A is a top section taken along section lines A-A of Figure 3. Figure 3B is a side section view taken along section lines B-B of Figure 3. Figure 3C is a side section view taken along section lines C-C of Figure 3.

[0019] Figure 4A is a top view of a set of linked segments in an actuated position, *i.e.* positioned against a coiled tubing. Figure 4B is a top view of the linked segments in a retracted position.

[0020] Figure 5 is a perspective view of a first type of contact surface for a segment.

[0021] Figure 6A is a top view of a segment of Figure 5. Figure 6B is a side section view of the segment of Figure 6A.

[0022] Figure 7A is a top view of a segment having a second, low stress contact surface. Figure 7B is a side section view of the segment of Figure 7A.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0023] Figure 1 illustrates the slip of the present invention in its intended environment. An actuator **10** includes a cylinder body **12** enclosing a cylinder chamber **14** having a piston **16** therein. A close port **18** directs hydraulic fluid pressure to one side of the piston to close the ram, and an open port **20** directs hydraulic fluid pressure to the other side of the piston to open the ram. The piston **16** connects to a rod **22** which terminates at a flange **24** which connects to a slip **26** of this invention, shown and described below in greater detail.

[0024] The slip **26** moves within a body **28** of a blowout preventer which is aligned along a center axis **30**. It is to be understood that a similar slip (not shown in Figure 1) is positioned opposite the slip **26** to enclose a coiled tubing **32** passing through the blowout preventer. Upon actuation, the slip **26** closes in around the coiled tubing **32** in a manner to be described below.

[0025] Figure 2 illustrates a complementary set of slips **26** and **26'**. In the following description, the components of the slip **26** will be described and it is to be understood that the slip **26'** includes the same structure. The flange **24** (Figure 1) mounts within a flange cavity **34** to move the slip by way of the actuator. The slip includes a slip body **36** to which are attached a first arm **38** and a second arm **40**. The arms **38** and **40** are mounted to the body with vertical pins **42** and **44**, also as shown in Figure 3C. The arms **38** and **40** are also pinned at their opposite ends by pins **46** and **48** to a stack of overlapping, articulated linked segments **50**. The linked segments are shown in Figure 2 in the

actuated position, in contact with the coiled tubing **32** centered on the axis **30**.

[0026] Note also the positioning of a set of articulated segments **70**, **72**, and **74** for ease of explanation of Figures 4A and 4B, described below.

[0027] Figure 3 shows a front elevation view of the stack of linked segments **50**. Each such segment has an arcuate interior surface **52** (See Figure 5) adapted to grip the outside surface of the coiled tubing **32**. The segments are offset from one row to the next, much as bricks are offset in the construction of a brick wall. As shown in Figure 3A, the pin **48** couples a segment **54** to the arm **40**, and the segment **54** also includes a pin **56**. A segment **58** is adjacent the segment **54** on the same layer, and includes pins **60** and **62** for rotational movement therewith. A segment **64** (See also Figure 3B), located below the segments **54** and **58**, is pinned to the pin **56** of segment **54** and the pin **62** of segment **58**, and thus is articulated in respect of these segments. T he other segments are similarly offset, from one layer to the next, down the stack.

[0028] The stacking of the respective linked segments is also illustrated in F igure 3 B. Each of the alternating layers overlaps the layer above and below it (except of course for the top and bottom layers), to provide full diameter contact between the surfaces **52** and the coiled tubing.

[0029] The slip body also includes line guides **66** on either side of the body for mating engagement with the o pposite slip body. The slip body may preferably include a line guide on the bottom of the body, and a similar line guide on the top of the body.

[0030] Figures 4A and 4B illustrate the actuation of the linked segments, from a retracted position, as shown in Figure 4B, to a closed position, as shown in Figure 4A. The arms **38** and **40** (Figure 2) are moved forward toward the axis **30**, thereby moving the pins **46** and **48** forward as well, and the articulated segments, linked together, collapse around the coiled tubing **32**.

[0031] Figures 5, 6A, and 6B depict a first embodiment of a segment **80** having the arcuate interior surface **52**. The surface **52** if preferably formed of substantially

horizontal threads **72** (Figure 6B) with vertical channels **74** cut through the threads to clear debris from the threads **72** and to avoid a continuous stress riser around the tubing. This arrangement somewhat resembles the interior surface of conventional slips, known in the art.

[0031] However, Figures 7A and 7B illustrate a new interior surface **82** of the presently preferred mode of the invention. The surface **82** preferably includes a plurality of molded cones **84** or cleats, each of the cones having a rounded apex, in order to properly grip the coiled tubing, while eliminating the scoring action of the threads of the embodiment of Figures 6A and 6B.

[0032] It should also be apparent to those skilled in the art that the present invention may find application in other operations requiring the gripping of coiled tubing which may not have uniform outer diameter. For example, the variable diameter, articulated gripper of this invention may be used in a coiled tubing injector, which requires the temporary gripping of the coiled tubing as it is injected into and withdrawn from the borehole.

[0033] The principles, preferred embodiment, and mode of operation of the present invention have been described in the foregoing specification. This invention is not to be construed as limited to the particular forms disclosed, since these are regarded as illustrative rather than restrictive. Moreover, variations and changes may be made by those skilled in the art without departing from the spirit of the invention.